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## PHOSPHORESCENT MARINE PRODUCTS

### Background of the Invention

During recent years, maritime activities both commercial and recreational have  
5 increased dramatically. As a consequence, visibility of marine articles is more  
important as U.S. bodies of water become crowded. The current means of increasing  
visibility of marine articles, such as, for example, buoy markers and boat indicators,  
include phosphorescent or fluorescent materials and brightly colored paints. However,  
these current means suffer from serious visibility and durability challenges.

10 Generally, the afterglow time of a fluorescent substance is short, i.e., the light  
emitted from the fluorescent substance decays immediately after removal from the  
source of excitation. Unlike such a fluorescent substance, some substances emit light  
after having absorbed ultraviolet radiation, and afterglow thereof that can be visually  
observed for a considerable time (ranging from several tens of minutes to several hours)  
15 after the source of stimulus is cut off. Such substances are called phosphorescent  
phosphors.

Phosphorescent phosphors are known. Sulfide phosphorescent phosphors are  
also known and include for example  $\text{CaS:Bi}$  (which emits light of violet blue),  $\text{CaStS:Bi}$   
(which emits light of blue),  $\text{ZnS:Cu}$  (which emits light of green) and  $\text{ZnCdS:Cu}$  (which  
20 emits light of green) and  $\text{ZnCdS:Cu}$  (which emits light of yellow or orange). However,  
many of these sulfide phosphorescent phosphors are chemically unstable and show

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degraded light resistance, i.e., they suffer from problems that must be solved for practical use.

The most extensively used phosphorescent phosphor among such sulfide phosphorescent phosphors is zinc sulfide phosphorescent phosphor (ZnS:Cu).

- 5 However, zinc sulfide phosphorescent phosphor is decomposed as the result of irradiation by ultraviolet radiation in the presence of moisture and thus, over time, blackens or reduces the phosphor's luminance. Therefore, it is difficult to use this phosphorescent phosphor in fields where it is placed outdoors and exposed to a direct sunlight, that is, application is limited to luminous clocks/watches or clocks/watches
- 10 and instrument dials, evacuation guiding signs or indoor night-time display.

- Even when zinc sulfide phosphorescent phosphor is used for a luminous clock, the afterglow allows the time to be visually recognized lasts only from 30 minutes to 2 hours. Therefore, the phosphorescent phosphor must be doped with a radioactive substance and a self-luminous paint to keep emitting light by absorbing the energy of
- 15 radiation from the radioactive substance.

- The use of brightly-colored paints, including fluorescent paints, on marine floats do not solve the visibility problem in darkness. Brightly-colored and fluorescent paints can only be seen if light is present to be reflected thereby. Also, these paints become eroded or worn from the relatively soft and pliable surface of microporous resinous or
- 20 foam marine floats, during use, so that any advantage which justifies the expense of applying such a paint is soon lost or severely diminished.

Thus, a need exists to develop phosphorescent marine products that provide long lasting afterglow characteristics, are chemically stable and physically durable in an outdoor marine environment.

### **Summary of the Invention**

5           The invention solves the prior art's visibility and durability problems of marine products by developing a highly visible and durable marine compatible product. In one embodiment, a marine article of the invention includes a phosphorescent phosphor. A particularly advantageous phosphorescent phosphor comprises  $\text{MAl}_2\text{O}_4$ . As used herein, "M" is at least one cation selected from a group consisting of calcium, strontium, and  
10   barium. The phosphor comprises 0.001% to 10% of a europium activator, and 0.001% to 10% of at least one dopant selected from the group consisting of lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, tin and bismuth as a co-activator, in terms of mol % relative to the metal element expressed by M. The phosphorescent marine article has an  
15   afterglow corresponding to a luminance of at least  $0.3 \text{ mCd/m}^2$  for at least 1000 minutes. In a preferred embodiment of the invention the phosphorescent phosphor is incorporated into a polymer forming a phosphorescent buoy or dock post cap.

### **Brief Description of the Drawing**

20           Figure 1 is a perspective view of a marine cap.

          Figure 2 is a front elevation view of a marine cap.

Figure 3 is a top plane view of a marine cap.

Figure 4 is a bottom plane view of a marine cap.

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### Detailed Description

A marine article includes a phosphorescent phosphor. A disclosure of one  
5 example of a phosphorescent phosphor suitable for a marine product of the invention is  
patent number 5,424,006 incorporated by reference herein. The phosphorescent marine  
articles described below show much longer afterglow characteristics that last longer  
than presently available phosphorescent marine articles and are chemically stable in the  
presence of moisture and UV light (marine environment).

10 It is important the marine article be visible throughout an entire night of  
darkness. This insures that marine articles are able to be seen and to alert aquatic users  
to dangers the marine articles are marking even in darkness. Typically the marine  
articles should display a visible afterglow for at least about seven-eight hours (420-480  
minutes), preferably greater than about ten hours (600 minutes), more preferably greater  
15 than about 1000 minutes. This length of time is adequate for a typical summer period of  
darkness for most regions. However, longer afterglow periods of time are desirable.

### The Phosphorescent Phosphor

One phosphorescent phosphor suitable in the invention is known commercially  
20 as "Luminova". "Luminova" is manufactured by Nemoto & Co., Ltd., of Japan. The  
present invention provides a phosphorescent phosphor which comprises a compound

expressed by  $MA_2O_4$  whose host material is a compound in which M is at least one cation selected from a group consisting of calcium, strontium and barium.

A phosphorescent phosphor which includes a compound expressed by  $MA_2O_4$  whose host material is a compound composed of a plurality of metal cations in which M is at least one metal cation selected from a group consisting of calcium, strontium and barium to which magnesium is added.

The phosphor contains 0.001 mol % to 10 mol % of a europium activator in terms of mol % relative to the cation expressed by M. The phosphor also typically contains 0.001 mol % to 10 mol % of at least one dopant selected from a group consisting of lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, manganese, tin and bismuth as a co-activator in terms of mol % relative to the metal element expressed by M.

The phosphorescent phosphor may show a glow peak of thermo-luminescence in a high-temperature region of 50° C or above when irradiated by ultraviolet or visible rays having a wavelength of 200 to 450 nm at room temperatures. The phosphorescent phosphor's afterglow remains visible for at least 1000 minutes. Visible is defined as a light intensity corresponding to a luminance of about 0.3 mCd/m<sup>2</sup>.

## The Marine Article

The Applicants have found the above described phosphorescent phosphor useful in a variety of marine articles. Examples of marine articles include dock accessories,

boat accessories, personal accessories, and floatation devices. Virtually any article that relates to outdoor water activities is useful in the invention.

Ans B27 One particularly useful marine articles are phosphorescent marine caps. Marine caps include buoy caps and dock post caps. These marine caps can mount on top of the buoy or dock post body. Figures 1-4 illustrate one embodiment of a preferred configuration of a marine cap. The overall appearance of the embodiment illustrated in Figures 1-4 is not exhaustive of appearances which are within the scope of the invention but are merely representative of one configuration which is ornamental but maintains some or all of the functional aspects of a marine cap of the invention.

10      Dock Accessory

Dock accessories are articles that are used in conjunction with the construction, operation, and maintenance of a dock or pier. An listing of dock accessories includes, for example, dock fenders, post fenders, bumpers, dock trim, step trim, cleats, ladders, post caps and dock lights.

15      Boat Accessory

Boat accessories are articles that are used in conjunction with the construction, operation, and maintenance of a boat, ship, or personal water craft. An listing of boat accessories includes, for example, bumpers, sails, masts, lettering, numbering, marine rope, trailer guides, trailer rollers, ladders, covers, shift knobs, throttle knobs, steering wheels and instrument gauges.

### Personal Accessory

Personal accessories are articles that are used in conjunction with the person while in a marine environment. An listing of personal accessories includes, for example, jackets, knives, coolers, drinking glasses, tools and patches.

### 5      Flotation Device

Flotation devices are articles that have the ability to stay on the surface of water. A listing of flotation devices includes, for example, buoys, buoy wraps, buoy caps, life jackets, floating key rings, ring buoy/life savers and floating cushions.

### 10      Tape

The phosphorescent phosphor can be incorporated into a tape. The tape can be affixed to a marine article using known methods. The tape can be a multi-layer film typically consisting of a phosphorescent backing, an adhesive and a liner.

### 15      Polymer

The phosphorescent phosphor can be incorporated into a polymer. An listing of useful polymers includes, for example, polycarbonates, polyethylenes, polypropylenes, polystyrenes, polyurethanes, copolymers of ethylene, copolymers of vinyl acetate, terpolymers of acrylonitrile, terpolymers of butadiene and terpolymers of styrene.

20      The manufacturing process for polymeric marine articles is typically a vacuum\thermoforming process although other methods are known in the art. The phosphorescent phosphor can be mixed with the liquid polymer to form the

phosphorescent phosphor/polymer mixture. The plastic can then typically be formed into sheets. The sheets are heated and placed over a mold. A vacuum pulls the sheet around the mold to form the marine article. Finally, the article is hardened by cooling the polymer. The phosphorescent phosphor/polymer mixture may also be formed into pellets that are extruded and further processed into the marine article using known methods. Injection molding is another common process for forming the marine articles of the invention.

The phosphorescent phosphor can also be incorporated into a paint such as a polyurethane paint. The phosphorescent phosphor paint may then be applied to the marine article to provide the luminance quality using known methods.

The above specification, and figures provide a complete description of the composition of the invention. Many embodiments of the invention can be made without departing from the spirit and scope of the invention.